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ABSTRACT

This study assessed the impact that reflective journals used in an introductory college science course had on preservice teachers' science literacy. Fourteen preservice teachers enrolled in an introductory physical science course taught using a variety of constructivist instructional methods (hands-on activities, cooperative group work, manipulatives, real life applications, field trips, group work, peer assessments, self-assessments, performance assessments, portfolios and weekly reflective journals). Preservice teachers' weekly reflective journals were collected and analyzed at the conclusion of the course. A focus group with the preservice teachers and an interview with the instructor were conducted. Data collected from the reflective journals and the focus group indicate that the use of constructivist instructional practices had a positive impact on preservice teachers' science literacy. Keeping a reflective journal helped the preservice teachers think more deeply about science in their everyday experiences. Further, this process of reflection had the additional benefit of increasing the relevance and application of the science concepts to their daily lives. These findings provide evidence that a college level science course taught using constructivist methods had a positive impact on preservice teachers' science literacy. (Contains 23 references.) (Author/DB)

ENHANCING THE SCIENCE LITERACY OF PRESERVICE TEACHERS THROUGH THE USE OF REFLECTIVE JOURNALS

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Abstract

This study assessed the impact that reflective journals used in an introductory college science course had on preservice teachers' science literacy. Fourteen preservice teachers enrolled in an introductory physical science course taught using a variety of constructivist instructional methods (hands-on activities, cooperative group work, manipulatives, real life applications, field trips, group work, peer assessments, self-assessments, performance assessments, portfolios and weekly reflective journals). Preservice teachers' weekly reflective journals were collected and analyzed at the conclusion of the course. A focus group with the preservice teachers and an interview with the instructor were conducted. Data collected from the reflective journals and the focus group indicate that the use of constructivist instructional practices had a positive impact on preservice teachers' science literacy. Keeping a reflective journal helped the preservice teachers think more deeply about science in their everyday experiences. Further, this process of reflection had the additional benefit of increasing the relevance and application of the science concepts to their daily lives. These findings provide evidence that a college level science course taught using constructivist methods had a positive impact on preservice teachers' science literacy.

Introduction

Undergraduate education and the quality of learning that takes place in college classrooms have been a central concern of many educators (Stage, Muller, Kinzie, and Simmons, 1998). These and other findings have led many colleges and universities to develop and implement reforms that center on improving teaching and learning. For example, reforms that include social learning experiences such as peer teaching and group projects, promote group construction of knowledge, allow a student to observe other students' models of successful learning, and encourage him or her to emulate them. Another reform stresses changing the instructional model from one that is lecture bound and teacher-centered to one that relies on strategies that more actively involve students in the learning process. Such student-centered models of instruction include methods that allow students to capitalize on personal strengths and interests, the use of sociocultural situations and methods that provide authentic contexts (e.g., such as the use of primary-source literature), and enculturation into an academic disciplinary community through authentic research.

These reform measures are central to the National Science Education Standards (NRC, 1996) where emphasis is placed on the development of inquiry skills, scientific thinking skills, as well as scientific content literacy through the use of a constructivist teaching methodology. This shift to a more constructivist way of viewing science has long existed in some colleges, but is now expanding to include many more colleges and universities where more meaningful and real-world applications of science are emphasized. These factors have been suggested to be central in the development of both conceptual understanding in science and to changing students' attitudes

toward science. Inquiry is central to science teaching to produce better conceptual understandings of science and greater interest in science. Inquiry is fostered when students are actively involved in the "doing" of science.

The goal of scientific literacy for all students is another core component of the National Science Education Standards (NRC, 1996). This concept proposes that a necessary role of introductory college science is to create citizens who understand science in ways that will enable them to participate intelligently in critical thinking, problem solving, and decision making about how science and technology are used by society. To achieve scientific literacy requires that instructors focus on problem solving embedded in students' own experience and awareness of local and cultural issues (Blosser, & Helgeson, 1990). Joanne Kurfiss (1988) has suggested a general design for courses that stress critical thinking skills. This design includes: (1) the course is organized around problems, issues, and questions, generally set in some realistic context for which there is no one "right answer;" (2) the course exposes students to multiple perspectives on each topic introduced; (3) the course challenges students' tendency to expect "answers" from professors or to assume that opinions are "good enough" when no exact answers are known; (4) students actively rehearse critical thinking skills needed to address the central problems of the course, almost always working with other students; and (5) the professor provides a support structure to help students learn how to address the problems posed in the course.

Another important factor included in the National Science Education Standards (NRC, 1996), teaching for conceptual change, emphasizes that scientific knowledge is meaningful to learners only when it is useful in making sense of the world around them. It is the role of conceptual change to help students develop meaningful, deep, conceptual understandings of science and its ways of describing, predicting, explaining, and controlling natural phenomena.

Through the process of challenging students' prior conceptions of scientific phenomena, students learn to construct new understandings based upon scientific principles. To accomplish this, the science curriculum must include investigations and activities designed to help students move from more intuitive understanding of how the world works to developing scientific concepts and ways of thinking. Instruction must integrate the processes of scientific investigation with conceptual knowledge and understanding. The methods of scientific investigation are employed within a conceptual framework to develop conceptual understanding. However, the emphasis is on the acquisition of understanding, not on rote memorization of methods, terminology, or facts. The emphasis on a conceptual-change model has its basis in knowledge resulting from research on how children learn (Anderson, Sheldon, & DuBay, 1986; Buckley, 1992; Camp, et al, 1994; Chi, Chiu, & deLeeuw, 1991; Clement, 1993; Mintzes & Arnaudin, 1984; Rea-Ramirez, 1998; Rea-Ramirez & Clement, 1997; Roth, & Milkent, 1989).

Finally, teaching critical thinking in science confronts both the epistemological and factual beliefs held by students that are grounded in the belief that learning involves mastery of a fixed body of authoritative information. Using approaches such as case-based studies, problem-based learning, primary literature debates, authentic research, and computer simulations, students are challenged with controversies. At first discovering that not all knowledge is factual may lead students to conclude that all opinions are equally valid. However, as they progress beyond this position, students explore competing perspectives that are consistent with experimental evidence.

Although many studies have stressed individual strategies, some of which are listed above, many innovative college educators believe that no one strategy best helps students to achieve both scientific literacy and a new appreciation of science. Rather, it is often a carefully planned combination of strategies that are open to the needs of the students and responsive to

their backgrounds and experiences. While theoretical ideals are important, they often do not answer instructors' questions of, " How do I integrate such ideals into the everyday working of the college science classroom? Or, "How can these ideals be used in large lecture classes?"

This study investigated an introductory college level science course to explore the role of reflective journals to enhance scientific literacy when combined with other constructivist strategies that were shown to increase preservice teachers' interest in science, critical thinking skills in science, and conceptual understanding of science (Gibson, Bernhard, Kropf, & Van Strat, 2001). This paper will discuss a key strategy (reflective journals) that may be used to enhance the learning environment and support success in college level science courses.

Background

Project UPDATE (an Urban Preservice Degree Articulation in Teacher Education) is collaboration between Springfield Technical Community College (STCC), the University of Massachusetts-Amherst School of Education, and the Springfield Public Schools. The project design addressed key issues of equity and multiculturalism for teachers and students in urban school districts. Specifically, urban districts have a disproportionately low number of teachers of color with respect to the student population. The project incorporates a curriculum designed around constructivist methodologies for the delivery of multiculturally rich, technologically relevant courses to paraeducators working in urban public education who want to earn a teaching certificate. The paraeducators continue to work full time as paraeducators while attending college part time.

In the first year of project UPDATE, three redesigned mathematics courses were offered at STCC during Summer and Fall 1998: Elementary Algebra I; Elementary Algebra II; and Math for Early Childhood/Elementary Teachers. Preservice teachers completed the three mathematics courses. Instructors of all three mathematics courses employed a wide range of instructional strategies, which included collaborative group work, problem solving, the use of manipulatives, and calculators. This series of constructivist mathematics courses had a positive impact on preservice teachers' attitudes towards mathematics (Gibson, Brewer, Magnier, McDonald & Van Strat, 1999).

In the Summer of 1999, a non-reformed Principles of Biology course was offered. Preservice teachers who completed the redesigned math courses enrolled in Principles of Biology. This course provided a significant contrast with the three reformed mathematics courses in that the biology course used a traditional lecture and note-taking approach. Subsequent research demonstrated that this biology course had a negative impact on the preservice teachers' interest in teaching science (Gibson, & Van Strat, 2000).

In the Summer of 2000, preservice teachers enrolled in a reformed college level Physical Science course. This course employed constructivist instructional methods, and was found to have a positive impact on preservice teachers' understanding of physical science concepts, attitude toward science teaching and learning, and critical thinking skills (Gibson, Bernhard, Kropf, & Van Strat, 2001). This paper will focus on how reflective journals used in this course impacted preservice teachers' science literacy.

Methodology

Participants

All fourteen preservice teachers, enrolled in the introductory Physical Science course, were women and worked full-time as paraeducators in an urban school district. Two were Russian emigrants, one was African American, five were Hispanic, and six were White. Seven of the fourteen UPDATE preservice teachers completed the Introduction to Physical Science course, the three reformed mathematics courses, and the Principles of Biology course. Thirteen were working on their Associate's degree at STCC, while one had already matriculated to the University of Massachusetts Amherst and was working on her Bachelor's degree. Paraeducators take courses during late afternoon and/or early evening to accommodate their work schedules. In addition, many of the paraeducators were single mothers. Usually paraeducators take 3 to 6 credits per semester. All but one of the preservice teachers expressed an interest in teaching at the elementary school level. Only one expressed interest in teaching at the middle/secondary school level.

Course Description

The reformed Physical Science course was taught using constructivist pedagogy including hands-on activities, cooperative group work, manipulatives, real life applications, field trips, group work, and authentic assessments (peer assessments, self-assessments, performance assessments, portfolios and reflective journals). Physical Science is a four credit, one semester class that met twice weekly for a total of eight hours per week.

The course was designed to introduce students to basic concepts of physical science. Nearly every class included hands-on science activities. These inquiry-based activities were

followed-up with classroom discussions and reflective writings. A textbook was used to supplement the in-class activities (Conceptual Physical Science - Hewitt/Suchocki/Hewitt). The textbook also served to reinforce concepts introduced during class activities, and to address ideas not specifically covered in class. In addition, students were given weekly homework assignments to engage and challenge them to improve their breath and depth of understanding of physical science concepts.

Journal writing assignments were given at each class meeting. At times journal assignments required students to think about science concepts before formal presentations. At other times, journals were used to make students reflect on observations made in class as well as asking them to make new observations outside of class. Journals were reviewed during one-on-one meetings several times during the semester. In addition, at the start of class the instructor asked students if they had any comments or questions about their journal assignments. This informal dialog set the tone and provided an introduction to the day's class.

A significant percentage of the final grade was based on self-assessment, peer assessment, and performance assessment. Written quizzes and tests emphasized scientific explanations and rationale rather than recall of facts. As the final assignment for the course each student was required to select a physical science concept, prepare a lesson, and present the lesson to the class.

Data Sources

A focus group with preservice teachers enrolled in Physical Science was conducted at the end of the course. All fourteen preservice teachers who were enrolled in the Physical Science course were present. The focus group collected information from preservice teachers about

project UPDATE and specifically about the Physical Science course. Participation in the focus group was voluntary and no members of the STCC staff were present. The focus group was audiotaped for transcription purposes only. The session lasted about 90 minutes. In addition, an informal interview was conducted with the instructor of the Physical Science course after the course had been completed.

Preservice teachers' reflective journals were collected at the end of the course. For the purposes of this study the journals were photocopied and returned to the preservice teachers. Also there was an exit survey administered requesting the following information: 1) Comment on the usefulness of the journals for learning, 2) How would you like to see this class be different? What changes do you suggest? 3) What should definitely not be changed?

Results

Focus Group

Responses of the preservice teachers during the focus group revealed the ways the instructional practices used in this course helped the preservice teachers to learn physical science concepts, to improve their critical thinking skills, to improve their attitudes toward science courses, and to improve their understanding of science. The following are excerpts from the focus group:

- *We used a lot of manipulatives in this course and that helped us learn science.*
- *The instructor always made sure to include examples of how physical science concepts were applicable to our everyday lives.*
- *A lot of time was spent on fewer science concepts.*

- *The instructor made us like science more because of the way the course was taught.*

Reflective Journals

Journal entries support the findings that the instructional practices used in this course helped preservice teachers appreciate science in their everyday lives, as well as helping learn science concepts. Their scientific literacy began to deepen as they developed new conceptual understandings. Each week the instructor assigned specific questions for the preservice teachers to address in their reflective journals. Following are a few examples of the types of questions the instructor (I) asked and samples of a few preservice teachers' (PT) responses to each assignment:

I: Describe a time when you were moving and had a very large acceleration. What was happening to you? How did you feel? (These questions were asked after the preservice teachers had learned about the following concepts: speed, velocity and acceleration)

PT: *One time when I had a very large acceleration was on a roller coaster ride. I was sitting in the car waiting for the ride to start when the car jerked forward and my whole body flew backwards. It was very scary.*

PT: *When I speed up in a car, slow down or turn I am accelerating.*

PT: *When I'm skiing on a high mountain acceleration is very large, because my speed rises gradually. Acceleration is a change in speed. I'm starting to move faster and speed up with every second, I am accelerating. It felt like it's hard to stop the acceleration unless I reach a flat surface, because there is no self-acceleration on it.*

The preservice teachers appear to understand that acceleration is a change in speed and yet some of them seem a bit confused about acceleration. Journal entries allow the instructor to find out what misconceptions are still lingering and to use this kind of information to help him/her

address these misconceptions in future lessons. For example one of the above preservice teachers appears to have some confusion about the relationship between speed and acceleration. She does not identify that slowing down is also another example of acceleration, which leads one to think that she may be identifying acceleration with an increase in speed. This is a rather common mistake that many people make because of the use of the word acceleration in everyday language. In science we give the word a different meaning, one that we believe she may not have adopted yet.

The following questions were asked after the preservice teachers had been introduced to Inertia and Newton's Laws of Motion.

I: What would it be like to live in the International space station? Here on Earth, everything is pulled toward the ground by a force called "gravity". How would a typical morning be different for you in this "weightless" environment?

PT: Well, I think first of all I would be floating as well as other objects. I know that food that I eat normally would be served differently, no plates, no forks. The food would be served in special tubes, and water would probably be in some special container. If you pushed an object it would fly across the room, not falling to the floor.

PT: I probably would have a hard time pouring myself a cup of tea. Would my shoes even be on the floor or would they be floating? When you brush your teeth, can you spit the water out into the sink or does it go everywhere? Would your hair when brushed stay down or would it float everywhere?

PT: I would wake up and have to undo the restraints that kept me stationary while I was sleeping. I would be floating and bumping into everything.

PT: I would be floating around, not walking. Could I take a shower? Do space stations have water to take a shower or bath? After floating around trying to get washed and dressed I would attempt to fix and eat breakfast. Drinking water or any liquids would be a challenge. This morning would have its moments. I must say I'm glad we have gravity.

These journal entries reflect a range of conceptual understanding attained by the paraeducators. Some preservice teachers understand the impact of living in an environment without gravity. Others understand some of the implications of living in a zero gravity environment, yet the interrogatories in their journals belie only partial mastery. Still others demonstrate few gains in their conceptual understanding of gravity and their journal entries contain nothing but questions. Having preservice teachers relate what they are learning in science classes to their real lives helps them integrate new understandings of science concepts into their view of the world. Journal writing made them think about the role of gravity in their everyday lives.

To gauge the impact of this course on students' scientific literacy, after a third of the course, the instructor asked preservice teachers to write in their journals using the following questions:

I: Since this class started, have you noticed yourself viewing anything differently? Reading a map? Describing the location or motion of some object? Noticing the interaction of objects? Describe an incident where you described or understood something differently because of something you learned in this class.

PT: Since this class started I have to admit that I am viewing things differently. For example, I think about chemical and physical changes that happen in my kitchen while I am cooking.

PT: Physical and chemical changes occur whenever heat is applied to food. For example, raw meat looks different when cooked. It changes its color, size, shape, taste, smell and texture. When heat is applied, the molecule move faster, some molecules separate, and some others get together. The fat from the meat when raw is solid, after it cooks some of the fat is liquid.

PT: I have noticed that I think more about why something is acting the way it is. I think more about what forces are acting on an object.

PT: I understand better that an object in motion tends to stay in motion until something stops it. A football thrown from the end of the field until caught at the other end zone is an example, although wouldn't it eventually fall to the ground due to gravitational pull?

The above examples reveal that the preservice teachers are beginning to view everyday occurrences with a more scientific perspective. This is evidence they are developing scientific literacy. In addition, reflective journals allow instructors to assess what concepts remain confusing to students. One preservice teacher above revealed that she was confused about an object in motion remaining in motion until acted upon by another force. At the time of this journal entry she did not fully understand that gravity was a force which could stop the football. It is notable here that she is posing a question. Part of scientific literacy is the ability to formulate questions. Once a question is formed than a hypothesis can be tested.

The following questions were asked after a lesson in which preservice teachers learned about buoyancy, density and how to determine the density of water.

I: An aircraft carrier is a huge structure, described as a "floating city". How does such a huge object stay on top of the water? Why doesn't it sink?

PT: An aircraft carrier stays a float because of buoyancy. It stays on top of the water because the water exerts an upward pressure in the direction opposite of the direction of gravitational pull. The aircraft carrier does not sink because the weight of the carrier is less than the buoyant force, the water. The water, the buoyant force is greater then the weight of the submerged object causes the object to rise to the surface and float this is called displacement.

PT: The buoyant force pushes on the carrier. The water being a liquid/fluid pushes up on the solid object (the carrier), as the object pushes the fluid out of the way. This is the strength displaced by the object.

PT: An aircraft carrier stays on top of water and doesn't sink because of its structure. The buoyant force is equal to the weight of the water displaced by the object.

PT: The reason why this huge structure does not sink is because the buoyant force is equal to the weight of the gravitational force. This is called displacement.

These journal entries indicate that while preservice teachers remembered and were able to use a lot of the vocabulary that they were introduced to in the lessons on buoyancy, some were still confused about the forces that were involved in floating. Having preservice teachers write in their journals about their understanding of the way ships float, allowed them to reveal any false conceptions that they might still have at this time.

The following questions were asked prior to covering the composition of matter, chemical changes and the interactions of matter and energy.

I: Observe some fireworks on the 4th of July. Describe the trajectories taken by the Fireworks as they are shot up and as they fall down. How do you think they get all those colors to come out? When viewed from some distance, you will notice a delay between when you see the explosions and when you hear the explosions. Why does that happen?

PT: The fireworks appear to be shot at a 45-degree trajectory high up into the sky through the use of gunpowder. After the explosion and a parabola form, pieces fall and the momentum seems to slow, with many different chemicals, which cause different colors. I am able to see the explosions before hearing them because light, which enables us to see, travels faster then sound.

PT: The fireworks have parabola shapes as they fall, this is because of gravity pulling down on them. The gunpowder sets off the fireworks. The colors are from certain elements mixed together.

PT: Most fireworks shot up at an angle. The colors are the chemicals or elements mixed together. The fireworks are a fuse, so once its ignited and goes up, its then you see the fireworks, its not until its elements are all used up when you hear the explosion.

These descriptions of fireworks reveal prior conceptions that the preservice teachers had before the composition of matter was discussed in this course. It is obvious that they have been exposed to the concepts of elements and understand somewhat about how the colors are formed as a result of the different substances in the fireworks. Instructors should find out what their students know before they plan lessons. Having the preservice teachers write in their journals about what they understood before a formal lesson about the composition of matter was a good way to find out what the preservice teachers already knew.

It is interesting to note that the preservice teachers were able to describe the shapes as the fireworks fell back to the ground. Earlier in the course, the preservice teachers were exposed to many examples of motion using graphs and strobe diagrams. They had learned about objects in "free fall". They were able to use what they had learned earlier in this course to describe the fireworks trajectories.

Exit Surveys and Interview with Course Instructor

Preservice teachers responses on the exit surveys indicate that they found keeping a journal useful to learning. Below are a few preservice teachers' responses to the following question asked on the exit surveys: Comment on the usefulness of the journals for learning.

PT: It helped me think more about what we had discussed in class.

PT: It made me feel safe to express my own opinion. I didn't have to worry about being right or wrong.

PT: I always wrote in my journal before reading the textbook. What I wrote was what I knew - or thought about something – I found that it made me sit and think about the topic given. I think that

journal writing is a great way to get children's thinking on paper. (Most students won't share their ideas verbally as they are embarrassed or think that they might answer wrong.)

PT: Using the journal I developed more confidence to write what I think and not be afraid of writing my own personal opinion.

PT: I liked writing in the journal because it gave me the opportunity to express my views and ideas.

PT: I liked writing in the journal because I knew no answer was wrong. I learned from reading my journal after classes about how I interpreted something differently. I could see how much I learned from the start to the end.

The journals were useful because the writing exercise forced them to reflect on the science concepts they were introduced to in class. Students require time to reflect on what they have learned to more fully understand science concepts. Comments made by the instructor echoed the preservice teachers' reflections, "The use of journals engages students outside of class and keeps their minds on the topics at hand. Keeping a journal requires students to reflect on their learning and this can lead to deeper conceptual understanding."

Conclusions

The data presented in this paper indicate that reflective journals when used with other constructivist instructional methods used in this Introductory Physical Science course increased preservice teachers' scientific literacy. Keeping a reflective journal provided the preservice teachers with an opportunity to participate actively in their own learning and gave them a safe place to express their own thoughts and feelings about science concepts. Additionally, journal writing provided the preservice teachers an opportunity to solidify their understanding.

For the instructor, reflective journals provide an opportunity to assess students' lingering misconceptions. This provides a base for planning future investigations that could either confirm or challenge their existing ideas and questions. Further, the instructor can gauge students' level of conceptual understanding of specific science topics studied in class. Another benefit for the instructor is that journals provide a graded incentive for students to think about a topic before and/or after class discussions. This is far from the traditional methods of science teaching, where an instructor covers the material, tests students, and moves on to the next topic regardless of whether students have really learned the intended scientific explanation.

Scientific literacy has less to do with memorizing facts and information and more to do with teachers and students communicating their understanding about science in their everyday lives. Written reflections are an effective and safe way for teachers and students to communicate with one another. Using science journals allows students to become more aware of their own efforts to make sense of science phenomena in the real world. In addition, journals also help students' practice formulating questions, which is an important part of scientific literacy.

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